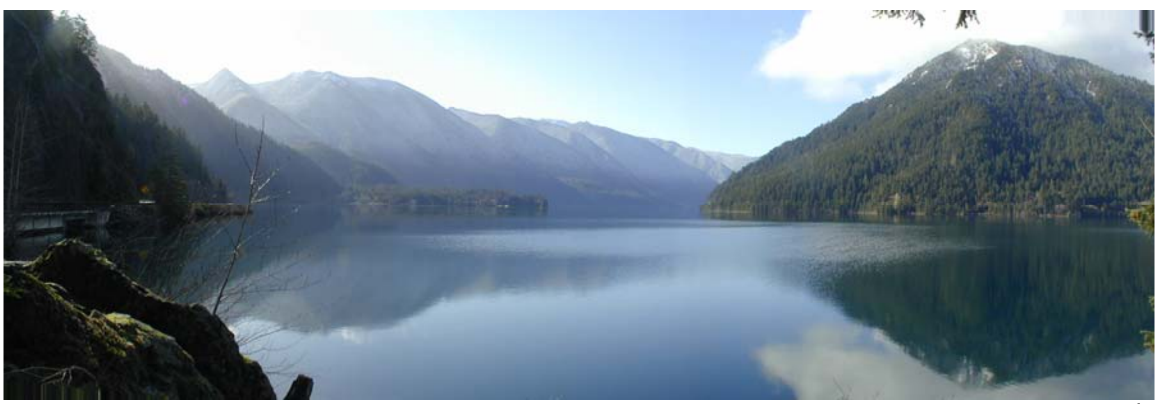
OLYMPIC NATIONAL PARK
NATURAL RESOURCE MANAGEMENT DIVISION
COASTAL BRANCH PROGRAM

NCCN LARGE LOWLAND LAKE MONITORING PROTOCOL



Lake Crescent, ONP

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Acknowledgments

Under Construction

This protocol is still ***<u>VERY</u>*** fluid…
Do check back after Jan 1, 2005!
What follows below are purely raw materials…

This protocol is a synthesis of many other protocols in use for monitoring lake systems in North America, and I thank those researchers for allowing me access to their protocols. In particular I wish to than Stephen Carpenter, Stephanie Hampton, Robert Hoffman, Jennifer Scheurelle, and Daniel Schindler for information on how they monitor the lakes of Wisconsin, Lake Washington, and montane lakes of the PNW.

John Boetsch was also instrumental in constructing the data dictionary and database designs.

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BACKGROUND AND OBJECTIVES

Background and history (describe resource issue being addressed)

- Large lakes while not numerous are important because define ecosystem
- By their nature, large lowland lakes in the NCCN have large surface areas and are deep
- The prime constraint in the development of this protocol is funding. In the absence of funding limitations a broader, more expansive program is possible and desirable. However, given reality, the protocol laid out here is a stand-alone reasonable protocol even if no further augmentation is possible.(This is different from expanding to more lakes given more funding).
- Because of limited network funding for this program, only one lake will be initially studied…. Lake Crescent in OLYM, However, contingent upon increased network funding, the protocols laid out here for Crescent will be expanded and implemented to the entire population of large lowland lakes.
- In this vein, the present protocol will be presented for lake crescent with appropriate additional guidance for how it may be altered/implemented for use in other lakes.

The protocol will be initially implemented at OLYM in Lake Crescent. Further implementation may proceed at NOCA.

- Lakes OLYM, NOCA: Greater than 50 ha surface area, with boat launch for sampling platform

NCCN Large Lowland Lake Population

NOCA	**Elevation(m)**	**Area (ha)**	**Depth (m)**
Chelan		13,500	433
Ross	487	4,726	155
Diablo	367	368	97
OLYM			
Ozette	9	2075	190
Crescent	177	3151	216

Rational for selecting this resource to monitor (reword this)

- Importance of large lake in NW ecoregion
    - Small number of large lakes in NCCN, however the lakes themselves are important waterbodies that the parks have a huge interest in maintaining their ecological integrity.
    - water quality, endemic/T&E species
    - Visitor use, charismatic
    - Long history of lake monitoring

Measurable objectives

- Parameters to be measured are a widely accepted suite
- "questions being asked are "reasonable" questions for a study of this sort.

<u>Large Lake Step-Down Framework</u>

- NCCN Water
    - Streams, Large Rivers, Montane lakes & Ponds
    - Large Lowland Lakes
        - Water Column
            - Physical/Chemical
                - N, P, pH, DO, Ions
                - T, SpCond, Secchi,
            - Biological
                - Zooplankton
                - Primary productivity (Chla)

        - Benthos
            - Bathymetry
        - Littoral
            - Littoral habitat
            - LWD distribution

<u>Monitoring Questions Associated with Step-down Framework</u>

- What is the status and trend of water quality in NCCN?
    - What is the status and trend of large lowland lake water quality in NCCN?
        - What are the temporal and spatial trends in physical/chemical characteristics of the lake water column (pelagic zone)? (*see attached table for physical/chemical parameters and sampling frequency*)
        - What are the temporal and spatial trends in the biological characteristics of the lake water column (pelagic zone)? (*see attached table for biological parameters and sampling frequency*)
            - What are the long-term trends in zooplankton species composition and abundance?
            - What is the natural level of variation in zooplankton species composition and abundance?
            - What are the long-term spatial and temporal trends in lake primary productivity?
        - What is the Bathymetry of a lake?
        - What is the current distribution of littoral habitats in a lake and what is the long-term change in this distribution?
        - What is the current distribution of LWD in a lake and what is the long-term change in this distribution?

Monitoring Objectives:

1. Determine seasonal and inter-annual changes in the horizontal and vertical distribution of physical/chemical characteristics of the lake water column. ***Justification*****:** *The spatial and temporal distribution of physical/chemical water column characteristics respond to a variety of system stressors, from point-source eutrophication to global climate change. Depending upon the type of stressor and basin morphology of the lake, different sections of the lake may be differentially affected. Understanding how these parameters change can provide park managers insight into potential causes, stimulate research to positively identify causes, and ultimately lead to beneficial management activities..*
2. Determine seasonal and inter-annual trends in zooplankton species composition, abundance, and distribution. ***Justification*****:** *Zooplankton communities respond to changes in lake trophic structure, pollution, and climate change. Understanding how zooplankton communities change over time can lead to better interpretation of changes in physical/chemical parameters.*
3. Obtain an accurate bathymetric map of a lake. ***Justification:*** *The number of water column sampling station per lake is dependent upon the number and size of sub-basins. Separated deep sub-basins may have different physical/chemical and biological dynamics. Knowing the basin morphology of a lake is crucial to developing an appropriate sampling design.*
4. Determine the distribution of littoral habitat types via periodic inventories to determine extent of shoreline modification. ***Justification****: Lake water quality and trophic structure can be affected by shoreline modification. Littoral habitat provides a buffer to terrestrial run-off, along with breeding and nursery habitat for key biota. Knowing the distribution of littoral habitat types and how they are changing over time will lead to more informed management decisions that directly affect lake water quality.*
5. Determine the distribution of LWD on the lake periphery. ***Justification*****:** *LWD provides key habitat for lake biota, including fish, that directly affect water quality. Knowing the current distribution of LWD and how it changes over time will inform management decisions that directly affect important lake biota and lake trophic structure.*

SAMPLING DESIGN

Because of the limited number of NCCN large lowland lakes and their widely varied characteristics the proposed monitoring design is a model-based rather than an inferential design. All large will be sampled so an inferential design is not needed. Moreover given the unique nature of the NCCN large lowland lake population, inferences drawn from an inferential design would be questionable.

Rationale for selecting this sampling design over others

- This design draws from classic and widely accepted lake monitoring programs
- Deviations from those programs are because each monitoring program has specific objectives that require tailoring of the design. For example, UWisc monitoring design in more of a research program, as is UWash's program. EMAP for lakes is a regional comparison… which is not appropriate for the NCCN due to the uniqueness of the small number of lakes

Site Selection

- Due to funding limitations only one lake is to be sampled initially in the NCCN.
- By their nature, large lowland lakes in the NCCN have large surface areas and are deep.
- Within a lake this protocol focuses on two lake aspects
    - (1) Pelagic biotic and abiotic structure (excluding fish communities which are monitored as part of a separate, coordinated park management protocol.
    - (2) Littoral habitat. Note that littoral communities and benthic habitat/communities are beyond the scope of this protocol due to staff/budget limitations

Criteria for site selection: define boundaries of population sampled

- The proposed large lowland lake monitoring consists of two components, (1) Regular water column physical/chemical and biological monitoring, and (2) Periodic inventorying of littoral habitat and LWD. Details related to sampling design, frequency and parameters are contained in the Table 2 (see below).
- Pelagic planktonic (zoop & phyto) and physical chemical properties
- Littoral: habitat types and LWD: Getting at effect of lake development/anthropogenic habitat modification. Expect this to move in a positive direction for LC since # of inholders and miles of road are not increasing.

Procedures for selecting sampling locations

- Pelagic emphasis here on a spatial design. Horizontal design = fixed stations in each major basin/sub-basin. Vertical design = vertical profiles or vertical integrated sampling at each station.
- Because of the limited number of NCCN large lowland lakes and their widely varied characteristics the proposed monitoring design is a model-based rather than an inferential design. All large will be sampled so an inferential design is not needed. Moreover given the unique nature of the NCCN large lowland lake population, inferences drawn from an inferential design would be questionable.
- The model-based design is also appropriate for within lake sampling. In order to characterize the pelagic areas of each lake, once wants to make sure one's sampling each of the major basins/sub-basins where things may be changing. For example, in lake crescent there are two large deep basins. Thus, there should be a sampling site in each of those basins. In addition there are 2 other sub-basins that adjoin the major basins which have substantial shoreline development. Thus it is desirable to make sure these are sampled.
- So, for pelagic… one sample station per major basin and important subbasins. For Lake Crescent this equals 4 fixed stations plus an additional station in the saddle point between the two major basins (sonde casts only).
- Regular water column monitoring will be conducted at fixed sampling stations located by GPS. The number of stations will be dependent upon the lake basin morphometry. Generally there will be a station in each major sub-basin, or major section of a sub-basin if sub-basins are extensive. Standard physical/chemical sampling will be conducted by taking a vertical profile of the water column with a multi-probe data sonde (e.g. YSI, Hydrolab). Additional chemical sampling will be conducted quarterly by taking epilimnetic, metalimnetic, and hypolimnetic water samples that will be shipped to an analytic laboratory for nutrient and ion analysis. See attached table for specific measurement parameters and sampling frequency.
- Littoral: emphasis here on habitat and spatial (linear) distribution around lake perimeter. Looking for change…

Sampling Frequency and replication

Here it is… The table below shows all of the parameters to be monitored what their frequency is and what the replication is.

Important to cover the following:

This protocol consists of two components, (1) Regular water column physical/chemical and biological monitoring, and (2) Periodic inventorying of littoral habitat and LWD. Details related to sampling design, frequency and parameters are contained in the Table X below.

Regular water column monitoring will be conducted at fixed sampling stations located by GPS. The number of stations will be dependent upon the lake basin morphometry. Generally there will be a station in each major sub-basin, or major section of a sub-basin if sub-basins are extensive. Standard physical/chemical sampling will be conducted by taking a vertical profile of the water column with a multi-probe data sonde (e.g. YSI, Hydrolab). Additional due to the budget limitations associated with the cost of send samples to outside analytical labs, chemical sampling will be conducted quarterly by taking epilimnetic, metalimnetic, and hypolimnetic water samples that will be shipped to an analytic laboratory for nutrient and ion analysis. These samples will also serve as a QA/QC on the YSI sonde measurements of ammonium and nitrate for those sampling periods.

Zooplankton communities will be sampled during the day by taking a vertically integrated sample of the water column during the day from depth of approximately 2 times the average annual secchi depth. This depth will ensure adequate sampling of the euphotic zone. However, it is recognized that this sampling may miss any zooplankter component that has vertically migrated to hypolimnetic waters during day. Sobeit. Phytoplankton biomass will be estimated via chlorophyll-a concentration profiles of the water column.

Periodic inventory of lake physical habitat characteristics also will be done. A bathymetric survey resulting in an accurate map will be conducted if such a map doesn't already exist. Once every decade littoral habitats will be boat-surveyed. Once every 5 years the distribution of large woody debris will be mapped.

Brief explanation of selected monitoring variables

Alkalinity is the capacity of water to accept protons, or the concentration of dissolved compounds to shift pH to a more basic level from and acidic level.

Anions and Cations are distinct charged dissolved chemicals that increase the specific conductance of water. Their measurement is often used as an indicator of atmospheric deposition of marine and anthropogenic ionic compounds and lake acidification.

Chlorophyll-a is a major photosynthetic pigment used by lake primary producers (e.g. phytoplankton). Measurement of cholorphyll-a concentration in lake water is an accepted surrogate for measuring algal biomass, which itself is an estimate of primary production. Direct measurement of algal biomass is problematic due to the large number of taxa present in a lake over the course of a year and the requisite taxonomic expertise and sample processing time needed to gather the data.

Dissolved Organic Carbon (DOC) is derived from the degradation of organisms and detritus that enters the lake ecosystem. DOC is an important resource base for the microbial component of lake ecosystems. Marked shifts in DOC can give insight into changes in DOC inputs, changes in microbial community structure, function, and abundance..

Dissolved Oxygen is an essential chemical for the support of key food web constituents (e.g. fish, zooplankton, algae, etc.) that respire aerobically. Lake eutrophication can increase aerobic demand causing low oxygen or anoxic areas that negatively impact aerobic organisms. Dissolved oxygen is a core water quality parameter required to be monitored by the NPS-Water Resources Division.

Lake Level is a measure of lake hydrology, specifically it is the sum of all water inputs (precipitation, streams, seeps, etc.) and all water outputs (drainage, evaporation, residential water use, etc.). Lake level is a valuable indicator of temporal changes in lake hydrology. Lake level is a core water quality parameter required to be monitored by the NPS-Water Resources Division.

Nitrogen is one of the essential nutrients in aquatic systems that fuels primary productivity and occurs in several forms that differ in the ability to be used by organisms. Nitrogen enrichment can lead to lake eutrophication. The forms monitored in this protocol are Ammonia (NH_4^+), total oxidized nitrogen (Nitrate-NO_3^- and Nitrite NO_2^-), and total Kjehldahl Nitrogen (organic nitrogen and NH_3). Ammonia arises as an end product of organic matter decomposition. Nitrite and nitrate are produce by bacterial oxidation of atmospheric nitrogen and ammonia. Nitrate is the most common state of nitrogen is lakes. Appreciable concentrations of nitrite are rare in most waters. The analyses employed in this protocol measure both nitrate and nitrite.

pH is a measure of the acid-base balance of water via the concentration of hydrogen ions. The water ionic composition determines pH, which is altered by atmospheric inputs, terrestrial runoff, and lake biogeochemical processes. pH has the potential to affect aquatic communities and biogeochemical processes. pH is a core water quality parameter required to be monitored by the NPS-Water Resources Division.

Phosphorus is a limited element in lakes and plays an essential role in biological metabolism. Phosphorus enrichment is a common cause of lake eutrophication. The forms monitored in this protocol are total phosphorus (suspended plus dissolved), total dissolved phosphorus (the component readily available for algal uptake), and othrophosphate. Orthophosphates are usually ions of phosphoric acid and originate from anthropogenic phosphorus compounds used in fertilizers.

Specific Conductance is a temperature-dependent measure water's ability to conduct and electrical current. It is the reciprocal of resistance. Increases in specific conductivity in a system may be associated with anthropogenic inputs to the system. Specific conductance is a core water quality parameter required to be monitored by the NPS-Water Resources Division.

Temperature is measure to characterize the ambient environment for aquatic organisms and to determine the pattern of thermal stratification of the water column. Due to density differences between water masses of different temperatures, the water column can become stratified during the summer and potentially during the winter in some systems. Stratification can lead to the accumulation of nutrients and decreases in dissolved oxygen in the hypolimnion. Spring and Fall mixing of the water column can lead to nutrient releases that fuel food web productivity.

Turbidity is the measure reduced light transmittance through water as a result of dissolved solids, pigments, algal biomass and suspended sediments. It is an alternate measure of water clarity.

Water Clarity (Secchi depth) is a measure of the transparency of water which is a surrogate measure of the cumulative concentrations of dissolved solids, pigments, algal biomass and suspended sediments. All of these factors can be altered by anthropogenic effects. The Secchi depth is a widely used measure of water clarity that measures the maximum depth at which a 20 cm diameter Secchi disk (with alternating black and white quarters) can be observed from the surface.

Zooplaknton are ubiquitous organisms found in the water column of lakes world wide. They are a central link be in lake foodwebs, transferring energy between primary producers and secondary consumers (ie. Fish, salamanders, etc.). Standardized methods exist for their rapid and accurate identification. Zooplankton biomass, species richness, community size structure, and abundance have been shown to be valuable indicators of lake ecosystem change.

Brief explanation of selected periodic inventory variables

Lake Bathymetry is important for determining where to place fixed sampling stations and understanding hydrodynamics. For any lake to be monitored a usable bathymetric map should be procured or constructed if it does not already exist. Ideally such a map would be incorporated into a GIS database.

Littoral Habitat is an important indicator shoreline changes due to anthropogenic shoreline modifications (e.g. bulkheads, beach construction, residential development, etc.) and natural changes (e.g. landslides, erosion, etc.). The change in the proportion of shoreline in various littoral habitat classifications is not expected to be great in the NCCN, so a periodic inventory on a decadal basis is recommended.

Large Woody Debris (LWD) is an important littoral feature that provides important habitat for fish and freshwater invertebrates. Anthropogenic shoreline modification (eg. Bulkheads, residential development, wood clearing, etc.) can degrade this habitat and impact foodweb interactions. The change in the proportion of littoral LWD is not expected to be great in the NCCN, so a periodic inventory on a 5-year basis is recommended.

Vital Signs Monitoring of Ecological Condition of Large Lowland Lakes

Target Population - Lakes OLYM, NOCA: Greater than 50 ha surface area, with boat launch for sampling platform

Two survey types: (1) Regular monitoring, (2) Periodic inventories

Orange denotes WRD required core parameters

	Survey Type		Sampling		
INDICATORS	**Reg Mon**	**Per Inv**	**# Stations**	**Sampling Frequency**	**Method**
Biological					
Zooplankton	m		2	monthly;3 reps/st	vertically integrated 60µm net. 2x mean S
Chlorophyll a	m		all	monthly	Data sonde: Vetically integrated fluorome
Physical					
Specific Conductivity	m		all	monthly	Data sonde:Vertically intergrated
Temperature	m		all	monthly	Vertically intergrated: Data sonde
Water Clarity (Secchi depth)	m		all	monthly	Secchi disk
Lake Level	m			continuous/weekly	Pressure transducer/ Staff gauge
Bathymetry		i		once	Sonar/GPS
Littoral habitat		i		decadal	Boat based survey/ Hi-res aerial photo
LWD distribution		i		every 5 yrs	Boat based survey/ Hi-res aerial photo
Chemical					
Dissolved Oxygen	m		all	monthly	Data sonde:Vertically intergrated
pH	m		all	monthly	Data sonde:Vertically intergrated
Turbidity	m		all	monthly	Data sonde:Vertically intergrated
Nutrients	m			monthly/quarterly	
-Ammonia			all	monthly/quarterly	Water sample: NPS lab w/data sonde
-Nitrate			all	monthly/quarterly	Water sample: NPS lab w/data sonde
-Total Kjehldahl Nitrogen			2	quarterly	Water sample: Offsite analytical laborator
-Total Phosphorus			2	quarterly	Water sample: Offsite analytical laborator
-Total Dislvd Phosphorous			2	quarterly	Water sample: Offsite analytical laborator
-Orthophosphate			2	quarterly	Water sample: Offsite analytical laborator
Anions and Cations	m		2	quarterly	Water sample: Offsite analytical laborator
Alkalinity	m		2	Quarterly	Water sample: Offsite analytical laborator
Dissolved Organic Carbon	m		2	quarterly	Water sample: Offsite analytical laborator

Recommended number and location of sampling sites

Place general info on number and location of sampling sites here. Generically, each major basin/sub-basin and other particular points of interest (historical monitoring sites and/or “transition” spots… although these should only be “free” sites, meaning sonde casts only)

For Lake Crescent:

Table 1: Coordinates for Lake Crescent (OLYM) fixed pelagic sampling stations.

Station	UTM E	UTM N
1	433028	5323883
2	440758	5326726
3	442775	5325936
4	441328	5323625
5	436752	5323030

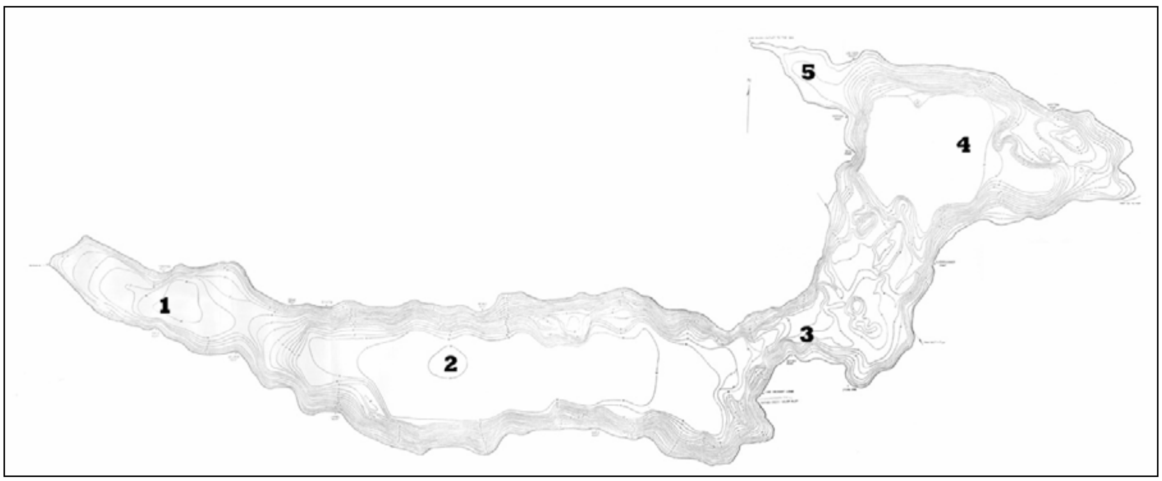

Figure 1: Bathymetric map of Lake Crescent (OLYM) showing location of pelagic monitoring stations.

Recommended frequency and timing of sampling

- See table.
- Briefly, pelagic zooplankton and physical/chemical water column characterization with the YSI data sonde occurs monthly.
- Off site analytical laboratory water chemistry sample are conducted quarterly
- See table for inventory stuff.

Level of change that can be detected for the amount/type of sampling being instituted. Yikes…hard question… Can this be ducked somehow? Need more data from lake to determine, but can also look at other studies… don’t have time to review these… depends upon the parameter… basically

- chemical parameters…. Over 5 year period x% change?
- Zooplankton: look at abundance which can be variable, but community structure and timing probably more important.
- Chla.
- Habitat. Likley very good.

- Hey: why not looking at periphyton?: In large lakes, periphyton is likely to show localized effects initially, given large lake perimeters, not feasible to adequately monitor, even with inferential design. Such localized effects would be (and have been) noticed and are in the realm of direct management actions outside of the auspices of this LTEM program.

FIELD METHODS

Field Season Preparations and Equipment.

Permitting and Compliance

All of the procedures associate with this protocol are expected to fall under a NEPA categorical exclusion for monitoring in parks. Prior to implementation, the park compliance officer should be consulted.

Prior to protocol implementation,

Prior to the beginning of each field season and continually during the season, all sampling equipment will be checked to ensure that it is in working order.

Sequence of events during field season

Below is a preliminary schedule of project-related activities:

Table 2: Sequence of events for monitoring-related sampling activities

Month	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Week	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
Hiring																								
Training																								
Quarterly Data Collection																								
Montly Data Collection																								
Data Entry																								
QA/QC																								
Reporting																								
Records Mgmt																								

Standard Operating Procedures (SOPs)

Large Lake Monitoring Field Equipment List

- YSI 6600 (with DO, pH/ORP and conductivity/temperature probes installed)
- Water proof cable cap for YSI 6600
- Bulkhead cup and field cage for YSI 6600
- Davit with steel line and hand crank
- Lowrance LC-X16$_{ci}$ GPS/Sonar unit
- P.F.D.s
- Clark-Bumpus Zooplankton sampler w/messenger
- 8 liter Van-Dorn water sampler w/ messenger
- Rope marked in meters
- Weight and carabineers
- Large Lake Monitoring Field form
- Field clipboard
- Limnology field note book

- Lugol's solution
- Coolers with ice packs
- 1000 ml previously labeled water sample jars
- 125 ml previously labeled zooplankton sample jars
- Squirt bottle
- Sharpie pens and pencil

Standard Operating Procedures

SOP #1: Water Chemistry Sample Collection: Offsite Analysis

- Two sites (Stations #2 and #4) are monitored quarterly at Lake Crescent, with single samples taken from the epiplimnion (top layer of the water column exposed to light), metalimnion (middle of layer including the thermocline during stratification), hypolimnion (bottom layer), requiring 6-500 ml and 6-250 ml bottles for each sampling period.
- Acid washed Nalgene bottles and pre-washed/dried filters are obtained from the offsite analytical laboratory (i.e. CCAL) and kept in a sterile environment.
- Samples should be kept in the dark and on ice from the moment they are collected.

1. **Sampling procedure**
    - **a.** Collect water sample from appropriate depth using a Van Dorn water sampling bottle.
    - **b.** Rinse the bottom portion of the filtration devicewith distilled water before each sample. Also rinse the small round filter holding plate with distilled water. Use forceps to handle the filter plate.
    - **c.** Rinse the upper portion of the filtration devicewith lake water from the site being collected.
    - **d.** Carefully place the filter paper on the filter plate using forceps. Improper placement of the filter paper will allow water to seep in around the filter.
    - **e.** Tighten the upper collection portion to the lower portion, making sure of a tight seal.
    - **f.** Using the 500 ml glass filtration flask, rinse with lake water and collect approximately 500 ml of water and pour into the filtration device.
    - **g.** Screw on the lid. Attach the vacuum pump to one of the fittings located on the side of the lower portion of the filtration device. Make sure the rubber caps are in place on ALL other ports (including the lid) to allow a vacuum to be created.
    - **h.** Pump the hand until water has been successfully filtered.
    - **i.** After all water has been collected in the lower portion of the filtration device, you must slowly release the pressure in order to unscrew the device. The best way to do this is to leave the pump attached and SLOWLY remove the rubber cap on the lower unit opposite from the vacuum pump attachment. The filter paper will be damaged, potentially allowing contaminants into the filtered sample if the pressure is released rapidly. By removing a cap from the lower portion of the device, the pressure will be pushed upward, and hence away from the sample thereby lowering the possibility of contaminants reaching the sample. Removing a cap from the lid will push the pressure toward the sample (BAD). Simply releasing the pressure valve on the pump handle drops the pressure too violently.
    - **j.** Rinse the 500 ml water bottle with a small amount of distilled water, then pour the filtered sample from the lower portion of the device into the Nalgene bottle, leaving approximately one inch of space near the cap to allow for expansion when frozen.
    - **k.** Rinse the 250 ml bottle with unfiltered lake water from the sample site, then fill the bottle leaving a small amount of open space at the cap to allow for expansion due to freezing. The 250 ml sample bottle is **NOT** filtered.
    - **l.** Label both bottles on the provided tape strip, with a unique sample identifier including both site and temporal information.
    - **m.** Repeat this procedure for each sample.
2. **Sample Processing**. Samples should be kept cold and in the dark. Samples should be FedEx'd to CCAL as soon as possible in a cooler using blue ice. Tape the lid shut in a secure fashion. CCAL should be notified a week prior to collecting samples in order to be prepared for their arrival. New filters and clean bottles can be sent back in the Park cooler from CCAL for use during the next sampling period.

SOP #2: YSI 6600 Data-sonde Calibration Protocol

Data Files: On both the sonde and computer after downloading from the sonde, all data files are named after the following convention.

Name = L**XMMDDYY**

Where X	=	C (for Crescent)
		O (for Ozette)
MM	=	Month (two digit)
DD	=	Day (two digit)
YY	=	Year (two digit)

Calibration materials:

Sonde Calibration Cup	**Old Calibration Standards**	**Rinsing Bucket**	**Kim Wipes**	**Distilled Water**
Conductivity Standard	**pH Standards**	**Turbidity Standard**	**Nitrate Standards**	**Ammonium Standards**

Procedure:

- To minimize the amount of calibration standard used, the YSI 6600 can be calibrated upright or upside down.
- For greatest accuracy rinse the calibration cup with dH20, then with a small amount calibration standard before each probe is calibrated.

Computer based calibration procedure

1) Secure 6600 to with ring stand and clamp next to table with PC.
2) Immerse probes into desired calibration solution and rotate calibration cup onto 6600.
3) Connect 6600 to PC with field cable and open Ecowatch program.
4) Select **sonde** from menu after **#**. Select **Com1** port
5) From Main Menu select **2-Calibrate.**
6) Select the number next to the parameter that you want to calibrate and press **Enter.**
7) Imput the Units of the calibration standard the you selected and press **Enter.**
8) A real time calibration screen will appear on the screen. When the readings have stabilized for over 30 sec. Press **Enter** to accept the calibration.
9) Press **Enter** to return to the calibration screen and continue with the next calibration.

Calibration of Sensors

- Calibrate sensors in the order listed in this protocol.
- Temperature sensor requires no calibration.

- Make sure that **only pH and temperature probes** come in contact with the pH calibration buffers. The salts in the buffer **WILL DAMAGE** the other sensors. Place the YSI issued protective caps on the other sensors while calibrating the pH sensor.
-

Amount of Calibration Standard Required

Probe to Calibrate	Upright	Upside Down
Conductivity	425 ml	225 ml
pH	300 ml	275 ml
Ammonium and Nitrate	300 ml	275 ml
Turbidity	130 ml	N/A
Chlorophyll a	300 ml	N/A

Units of Calibration Standards

Calibration Standard	Units
Conductivity	1 ms/cm
pH	7 – 10
Ammonium and Nitrate	10 mg/mL – 1 mg/mL
Turbidity	***10 NTU – 0 NTU***

Conductiviy Probe

1) Add 225 mL of 1 mS/cm conductivity standard to the calibration cup and secure to 6600 data sonde. Rotate 6600 data sonde to an upside down position so the conductiviy sensor is immersed in the calibration standard.

2) Gently rotate to remove any bubbles from the conductivity sensor.

3) Wait one minute for temperature equilibrium.

4) From the Calibrate menu, select **1-Conductivity,** and then **1-SpCond** .

5) Enter **1 ms/cm at 25° C** for the calibration standard, then press **Enter.**

6) Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the next sensor.

Dissolved Oxygen Probe

1) Place approx. 3 mm of dH2O in the bottom of the calibration cup. Lightly twist calibration cup onto only the first to threads of the 6600 data sonde.

2) Wait 10 min. for the air in the calibration cup to become saturated.

3) From the Calibrate Menu, select **2-Disssolved Oxy**, then 1**-DO%**.

4) Enter current barometric pressure in mm of Hg (Inches of Hg x 25.4 = mm Hg). **Make sure that the barometric pressure readings are not corrected to sea level for Lake Crescent measurements**.

5) Press **Enter** and Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the next sensor.

Depth and Level

1) From the Calibrate Menu, select **3-Pressure-Abs.** Input **0.0** and press **Enter**.

2) Press **Enter** and Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the next sensor.

pH Probe

1) Add 300 mL of pH 7.0 buffer to the calibration cup and secure to 6600 data sonde. Wait 1 min for temperature equilization.

2) From the Calibrate Menu, select **4-ISE1 pH** then press **2-2-Point.** Press **Enter** then input **7** for the value of the buffer and press **Enter**.

3) Wait for the PC to calibrate the pH sensor to 7.0. When finished press **Enter**.

4) Rinse the pH sensor in dH2O and dry with a kimwipe.

5) Add 300 mL of pH 10.0 buffer to the calibration cup and secure to

6) Press **Enter** and input 10 as the value of the second buffer.

7) Press **Enter** and Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the next sensor.

Ammonium and Nitrate Probes

1) Add 300 mL of 10 mg/L calibration solution to the calibration cup and secure to 6600 data sonde. Wait 1 min for temperature equilization.

2) From the Calibrate Menu, select either **6-Ammonium or 7-Nitrate** then press **2-2-Point.** Press **Enter** then input 10 mg/L for the value of the calibration standard and press **Enter**.

3) Wait 30 sec. for the readings to stablize, then press **Enter**.

4) Rinse the sensor in dH2O and dry with a kimwipe.

5) Add 300 mL of 1 mg/L calibration solution to the calibration cup and secure to 6600 data sonde. Wait 1 min for temperature equilization.

6) Press **Enter** and input 1 mg/L as the value of the second buffer.

7) Press **Enter** and Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the next sensor.

Turbidity Probe

Add 130 mL of dH2O to the calibration cup and secure to 6600 data sonde.

From the Calibrate Menu, select **8-Turbidity**, then **2-2-Point**

Input the value **0.00 NTU** at the prompt and press **Enter**.

Activate the wiper by pressing **3-Clean Optics**.

Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to start the calibration of the 10 NTU standard.

Dump the dH2O from the calibration cup, dry all the sensors carefully with a kimwipe, then add 130 ml of the 10 NTU standard to the calibration cup and secure to 6600 data sonde.

Input the value **10.00 NTU** at the prompt and press **Enter**.

8) Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to return to the calibration menu.

9) The 6600 data sonde is now ready for action!

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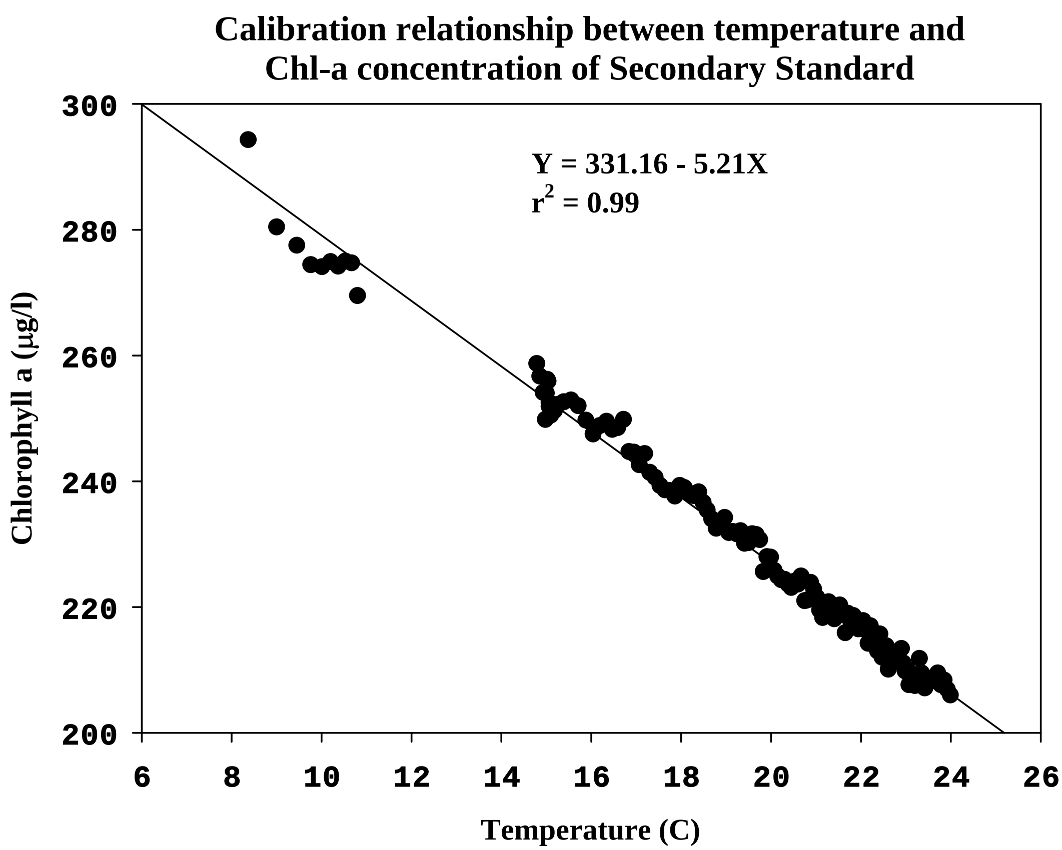
Chlorophyll Probe

1) Add 130 mL of dH2O to the calibration cup and secure to 600 data sonde.
2) From the Calibrate Menu, select **9-Chlorophyll**, then **2-2-Point**
3) Input the value **0.00 µg/l** at the prompt and press **Enter**.
4) Activate the wiper by pressing **3-Clean Optics**
5) Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to accept.
6) Dump the dH2O from the calibration cup, dry all the sensors carefully with a kimwipe, then add 300 ml of the secondary chlorophyll standard to the calibration cup and secure to sonde.
7) Note temperature and compute chlorophyll equivalent value for secondary standard from equation in graph below. Input the value at the prompt for the second point and press **Enter**
8) Wait for the calibration readings to stabilize for 30 sec. then press **Enter** to return to the calibration menu



Preparation for Field Deployment

1) Remove field cable and affix cable port screwcap.
2) Remove sonde from calibration station and place in field case.

SOP #3 Zooplankton

- Standard zooplankton samples will be fixed with acid Lugol's solution. Samples thus fixed are stable for at least 6 months if refrigerated. Formalin is not used in these samples because it is highly carcinogenic, requires working in a fume hood, and worker exposure to it should be minimized.
- Formalin is used only to fix voucher specimen samples. In these samples a 5% sugar formalin solution is used. Samples thus fixed can be kept unrefrigerated for multiple years.

A) Sample Collection

- Record zooplankton sampling and depth of each replicate on the Lake Monitoring Field Form (see Appendix x).
    a. Three replicate zooplankton samples are collected from each of two stations (Stations #2 and #4).
    b. Zooplankton samples are collected using a Clarke-Bumpus zooplankton sampler fitted with a 60 µm mesh net.
    c. The zooplankton sampler is deployed to 40 m (2x the average Secchi depth)
    d. A messenger is sent to open the sampler
    e. The sampler is retrieved at a steady pace (~0.5 m/s)
    f. Zooplankton are further concentrated in the cod end and rinsed into the previously labeled sample bottle.

g. Approximately 1 ml of Lugol's solution is added to the sample giving it the color of strong tea.
h. The sample is stored in the cooler for transport back to the laboratory.
i. Once at the laboratory all samples are transferred to the dedicated sample refrigerator

B) Sample Labeling: Each sample will be labeled with the following unique identifier:

LXR**Ymmddyy##**

Where X = Lake (C for Crescent)
Y = Replicate number (1-3)
mm = month (2 digit)
dd = day (2 digit)
yy = year (2 digit)
= length of vertical tow

C) Sample Processing
a. Use Plankton enumeration form (see Appendix x)
b. Bring sample to a standard sample volume (i.e. 50 ml)
c. Thoroughly mix sample and remove a l ml aliquot with a wide bore pipet (i.e. Hensen-Stempel pipet). Place aliquot in counting chamber
d. Count all zooplankton taxa under 50x magnification and record data.
e. Repeat counting of additional aliquots until at least 100 individuals of the most common taxon (e.g. a daphnid) have been counted and at least 25 individuals from the other relatively abundant taxa (e.g. rotifers, copepods) have been counted, or at least 10% of the total sample volume has been counted.

SOP #4 Secchi depth

- The Secchi depth is recorded at all fixed sampling stations.

1) Use an aqua-tube for viewing the secchi disc in the water. An aqua-tube is a tube with a clear Plexiglas bottom that allow the observer to view underwater without interference of surface glare.
2) Attach 5lb weight to Secchi disc bottom to keep line straight at depth.
3) Lower Secchi disc on attached line marked in meters on the shaded side of the boat until the point where the disc is no longer visible. Note the depth.
4) Lower the disc beyond this point. And slowly raise the disc until it just reappears. Note this depth.
5) Record the average of the two depth measurements as the Secchi depth.

SOP #5 Data sonde deployment

- The data sonde is deployed at all fixed stations
- At each station two sonde casts are taken due to different depth limits of probes (see table).
- The ammonia and nitrate probes are never deployed in the field. These probes are only using in the NPS lab on water samples collected from depth.
- The first cast with Chl-a and turbidity probes installed is deployed to a max depth of 60 m.
- The second cast with Chl-a, turbidity probes removed is deployed to a max depth of 200 m (usually within 5 m of the lake bottom).
- Prior to deployment in water make sure that sonde is securely fastened to cable with a locked carabineer
- Prior to sonde deployment make sure that cable and attachments appear sound. Bent deformed steel cable can snap due to stress articulation on a singe point.
- At each st

1) Attach armed sonde and 10 lb weight to cable and swing davit overboard.
2) Let out line dropping sonde to target maximum depth (dependent upon probes installed and bathymetry). Monitor depth using boat's sonar display.
3) Arrest sonde descent at target depth. Using the hand crank raise the sonde at a rate of ~ 0.5 m/s.
4) Bring sonde into boat and adjust probe array according to sample schedule.

Table 3 YSI Sonde Probe Depth limits

Probe	**Depth**

Ammonia	14 m
Nitrate	14 m
Chl-a	61 m
Turbidity	61 m
DO/pH/SpCond	200m

Example field forms appear in appendix X

Include something here on the preservation of voucher specimens with citation (Stemberger & Prepas).

End of season procedures

- There really isn't an end to season per se, rather there is an end to the cycle in October. At this time data are collated and analyzed for reporting.
- Also at this point one needs to do an accounting of calibrations standards needed for the next year.
- Every three years the data sonde sent back to YSI for factory certified calibration??
-

PERSONNEL REQUIRMENTS AND TRAINING

Roles and responsibilities

The large lake monitoring program requires a full time aquatic ecologist, and a full time technician who devotes 5pp per year to the project over the course of a year. A part-time technician or student employee is required for 2-3 pp during the summer to process samples. NPS laboratory analyses are conducted by either the full time technician or the aquatic ecologist. Offsite water chemistry analyses are conducted by a certified analytical laboratory. Data analysis and reporting are the responsibility of the aquatic ecologist.

Qualifications

The aquatic ecologist must be a trained limnologist with a background in taxonomic identification. For example, the aquatic ecologist at OLYM has both an M.S. and a Ph.D. in limnology. The full-time technician must have an undergraduate degree in aquatic ecology and previous experience conducting limnological research. The part-time technician must have previous experience conducting biological field work.

Training

Technicians must go through a training period with the aquatic ecologist. The full time technician will work directly with the aquatic ecologist until the aquatic ecologist is satisfied that the technician is capable of operating independently. The part-time technician will always work directly with either the aquatic ecologist or the full-time technician. Zooplankton samples will either be analyzed by the aquatic ecologist or by a technician after appropriate training. This training will include working with voucher specimens and a period of sample checking by the aquatic ecologist.

Operational Requirements

Annual workload and field schedule:

Facility and equipment needs

In order to conduct the work involved in the protocol a rudimentary lab facility and certain equipment is necessary.

<u>Major Essential Equipment</u>

- A multi-probe data sonde (eg. YSI 6600 w/ appropriate probes)
- Boat for sampling (e.g. 17 ft Boston Whaler)
- Davit with steel line and hand crank
- GPS/Sonar unit (e.g. Lowrance LC-X16$_{ci)}$
- P.F.D.s

- Vertically integrating zooplankton sampler (e.g.60um plankton net, Clark-Bumpus sampler etc.)
- Van-Dorn water sampler
- Dissecting microscope (e.g. Zeiss Stemi-2000C)
- Compound microscope (optional, e.g. Nikon E400)
- Folson plankton splitter

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Large Lowland Lakes Protocol Database
Data Dictionary
Draft - December 13, 2004

Note: This information is in draft and is subject to change. Upon completion, additional documentation of database features for data entry, processing and validation and automated reporting will be provided.

Data dictionary terminology and shorthand

Formats and characters

- **darkened** sections indicate fields, data types and definitions that are standardized across multiple project databases
- an **asterisk** (*****) indicates that the field is part of the primary key for the table
- ***italics*** indicates that the field is indexed for faster searching and sorting
- a **hatch mark** (`) indicates that the field is a foreign key (i.e., a primary key from another table, used to establish relationships between tables)
- a **dagger** (†) indicates that the field name, format and/or definition standards are under development and subject to change

Data types

- **GUID** stands for globally unique identifier, a combination of a very large random number and date that is very unlikely to be repeated twice in a database; useful for primary keys in cases where multiple copies of a database are maintained
- **auto-number** is a sequential or random integer applied by the database every time a new record is added to a table; useful for primary keys in cases where there is only one database copy
- **txt** means a text field, with a number to indicate the number of characters that can be stored (from 1 to 255)
- **memo** means a long text field that can accommodate up to 65,535 characters or 1 gb of data
- **date/time** is a special type of numeric field for storing dates and times from the year 100 to 9,999
- **boolean** is the most compact data type, for storing binary data (yes/no, true/false)
- **integer** is a numeric field that can store whole numbers ranging from –32,768 to 32,767
- **byte** is a short integer format, storing whole numbers from 0 to 255
- **long integer** is an integer format that can store whole numbers ranging from –2,147,483,648 to 2,147,483,647
- **single** is a floating-point numeric field type, for storing values with precision up to seven decimal places
- **double** is a floating-point numeric field type, for storing values with precision up to 15 decimal places
- **decimal** is a fixed-point numeric field type, for storing values with precision to 28 decimal places
- **OLE** is a field type that can accommodate objects such as Word documents, graphics, sounds, or other binary data; objects are either linked or embedded and stored in the database

Data dictionary

Sites (Lakes): tbl_Sites		Standard table listing the general sites for data collection
**Site_ID*	GUID	Unique identifier for each site
Site_name	txt 50	Brief colloquial name of the site
Park_code	txt 4	Park code in which the site is located
State_code	txt 50 †	State in which the site is located
County	txt 50 †	County in which the site is located
Quad_code	txt 50 †	Quadrangle in which the site is located
Basin_code	txt 50 †	Watershed in which the site is located
Site_notes	txt 255	Comments about the site

Sample Locations: tbl_Locations		Standard table describing the specific places where data collection occurs
**Location_ID*	GUID	Unique identifier for each sampling location
`Site_ID	GUID	Site at which the sample location is found
Location_name	txt 50	Brief colloquial name or field code for the sample location
Location_type	txt 25	Indicates the type of sample location: fixed (used for relocating sample positions over time), incidental (used for one-time data collection) [default: fixed]
Location_notes	txt 255	Notes about the sample location
Is_active	boolean	Indicates whether the sample point is still in use for sampling and data entry
Date_established	date/time	Date on which the sample location was established
Date_discontinued	date/time	Date on which the sample location was discontinued
Created	date/time	Time stamp for record creation

Coordinates: tbl_Coordinates		Coordinate data for sample locations
**`Location_ID*	GUID	Unique identifier for the sampling location
**Coordinate_date*	date/time	Date on which the coordinate data were collected
Is_current	boolean	Indicates whether this set of coordinates is the best and most current for this location
X_coordinate	double	Easting or longitude
Y_coordinate	double	Northing or latitude
Coord_system	txt 50	Coordinate system: Latitude/Longitude, Universal Transverse Mercator (default), State Plane
Datum	txt 5	Datum of the mapping ellipsoid: NAD83, NAD27
Coord_zone	txt 5	Coordinate zone – especially UTM zone
Coord_source	txt 50	Means by which coordinates were acquired: GPS, digitized from DOQ, digitized from quad, map overlay, random selection, other
GPS_type	txt 50	Type of GPS unit used to collect coordinates: Trimble Geo2, Trimble Geo3, Trimble ProXR, Lowrance GPS/Sonar (default), …
Is_diff_corrected	Boolean	Indicates whether the GPS data are differentially corrected (either real-time or post-processed)
Est_horiz_error_m	single	Estimated horizontal accuracy, in meters
Accuracy_notes	txt 255	Notes about the accuracy of the coordinates
Coordinate_notes	txt 255	Notes about this set of coordinates

Created	date/time	Time stamp for record creation

Sampling Days: tbl_Sample_Periods		Standard table describing the span of dates during which data collection takes place
**Period_ID*	GUID	Unique identifier for the sample period
`Project_code	txt 20	Project code, for linking information with other data sets and applications
Start_date	date/time	Start date of the sample period
Start_time	date/time	Start time of the sample period (optional)
End_date	date/time	End date of the sample period
End_time	date/time	End time of the sample period (optional)
Trip_description	txt 255	Brief description of the purpose, intent, etc. of the trip (optional)
Trip_notes	memo	Details about the trip
Trip_report	OLE	Linked or embedded document describing the details of the trip

Sampling Events: tbl_Events		Standard table describing each data collection event
**Event_ID*	GUID	Unique identifier for the data collection event
`Location_ID	GUID	Sampling location associated with this event
`Period_ID	GUID	Sample period during which this event occurred
Start_date	date/time	Start date of the sampling event
Start_time	date/time	Start time of the sampling event
End_date	date/time	End date of the sampling event
End_time	date/time	End time of the sampling event
Secchi_depth_m	single	Depth in meters at which visibility of the submerged secchi disk becomes obscured to a surface observer
Event_notes	memo	Comments about the sampling event

Observers: tbl_Observers		Standard table listing the observers for each sampling event
**`Event_ID*	GUID	Unique identifier for the data collection event
**`Contact_ID*	txt 50	Name of the observer
Assignment	txt 50	Role of the observer during data collection (optional)
Observer_notes	txt 255	Comments about the observer

Quality Assurance: tbl_Event_QA		Standard table for quality assurance details about the event
**`EventID*	GUID	Unique identifier for the data collection event
Entered_by	txt 50	Name of the person who entered the data for this event
Entered_date	date/time	Date on which data entry occurred
Updated_by	txt 50	Name of the person who made the most recent updates to data for this event
Updated_date	date/time	Date on which the most recent data updates occurred
Verified_by	txt 50	Name of the person who verified data accuracy for this event
Verified_date	date/time	Date on which data accuracy reviews occurred
QA_notes	memo	Comments about the quality assurance for this event

Sondes: tbl_Sondes		Vertical profile deployments of the multi-probe sonde
**Sonde_ID*	GUID	Unique identifier for each record
`Event_ID	GUID	Unique identifier for the data collection event
Deployment_time	date/time	Start time of the sonde deployment

Filename	txt 50	Sonde data logger file name
Upload_date	date/time	Date on which the file was uploaded to the database
Uploaded_by	txt 50	Name of the person who uploaded the file into the database
Sonde_notes	txt 255	Comments about the sonde deployment

Sonde Data: tbl_Sonde_Data		Automated data recorded by the multi-probe sonde
**Sonde_datum_ID*	GUID	Unique identifier for each record
`Sonde_ID	GUID	Unique identifier for the sonde deployment
Obs_time	date/time	Time (hh:mm:ss) at which the sonde measurement was recorded
Obs_depth_m	single	Depth (meters) at which the sonde measurement was recorded [valid range: 0-300]
Water_temp_C	single	Water temperature, in Celsius [valid range: 0-40]
pH	single	pH [valid range: 1-15]
Conductivity_uScm	single	Conductivity, in micro-Siemens per centimeter [valid range: 0-1000]
Turbidity_NTU	single	Turbidity, in nephelometric turbidity units (NTUs) [valid range: 0-600]
Diss_oxygen_mgl	single	Concentration of dissolved oxygen, in milligrams per liter [valid range: 0-40]
Ammonia_ugl	single	Concentration of ammonia, in micrograms per liter [valid range: 0-3000]
Nitrate_mgl	single	Concentration of nitrate, in milligrams per liter [valid range: 0-50]
Sonde_QA_flag	txt 50	Quality assurance flag
Sonde_datum_notes	txt 255	Comments about this sonde measurement

Zooplankton Samples: tbl_Zooplankton		Zooplankton sample replicates
**Zooplankton_sample_ID*	GUID	Unique identifier for each record
`Event_ID	GUID	Unique identifier for the data collection event
Replicate	byte	Sequential replicate number (e.g., 1, 2, 3, etc.)
Processed_by	txt 50	Name of the person who processed the sample
Process_date	date/time	Date on which the sample was processed
Total_vol_sampled_l	integer	Total volume sampled, in liters [default: 1386, valid range: 0-10,000]
Sample_vol_ml	integer	Volume of the concentrated sample, in milliliters [default: 50, valid range: 10-100]
Aliquot_vol_ml	integer	Volume of aliquots taken from the concentrated sample, in milliliters [default: 1, valid range: 1-10]
Zooplankton_notes	txt 255	Comments about the zooplankton sample

Zooplankton Data: tbl_Zooplankton_Data		Zooplankton taxon occurrence data
**Zooplankton_datum_ID*	GUID	Unique identifier for each record
`Zooplankton_sample_ID	GUID	Unique identifier for the zooplankton sample
`Taxon_ID	GUID	Zooplankton taxon
Individuals_n	integer	Number of individuals observed in the sample aliquots [valid range: 0-1000]
Aliquots_n	byte	Number of aliquots taken from the sample [valid range: 1-10]
Zooplankton_datum_note	txt 255	Comments about this record

All Taxa: tbl_Taxa		Centralized list of taxa and cross-referenced synonyms
Taxon_ID	GUID	Unique identifier for the taxon record
TSN	long integer	ITIS taxonomic serial number or a provisional number assigned within the NPSpecies database
TSN_accepted	long integer	Indicates the accepted name for this taxon
Category †	txt 25	General category of the taxon, equivalent to the categories used in the NPSpecies database
Subcategory †	txt 25	Subcategory specific to the needs of each taxonomic discipline
Sci_name †	txt 100	Scientific name of the taxon
Authority †	txt 75	Taxonomic authority
Sub_authority †	txt 75	Taxonomic authority for subspecific taxa
Com_name †	txt 100	Common or vernacular name for the taxon
Taxon_notes	txt 255	General comments about this taxon
Taxonomy_notes	txt 255	Notes regarding the taxonomy and nomenclature of the taxon
Family †	txt 50	Taxonomic family
Origin †	txt 25	Native, non-native, unknown, or unspecified (default)
Record_status	txt 25	Indicates the disposition of the taxon record in terms of internal review and synchrony with NPSpecies and ITIS: new record (default), in review, synchronized, final
Status_notes	txt 255	Notes about the disposition of the record
Representation	txt 25	Indicates the taxonomic resolution and certainty represented by this record: single taxon (default), grouped taxa, or a temporary name
Group_rationale	txt 50	If the record represents grouped taxa, the rationale for grouping taxa is indicated: functional similarity, commonly confused, not distinguishable during data collection, other
Group_notes	txt 255	Comments about the grouping of taxa
Created	date/time	Date on which this taxon record was created

Project Taxa: tlu_Project_Taxa		Lookup table of taxa associated with this project
**Taxon_ID*	GUID	Unique identifier for each taxon
**Project_code*	txt 20	Project code, for linking information with other data sets and applications
Field_code	txt 25	Field code or abbreviation for the taxon name; often a concatenation of abbreviated genus and specific epithet names
Project_taxon_notes	txt 255	Notes about the project-specific usage of this taxon
Is_active	boolean	Indicates whether the taxon record is currently active and available for data entry pick lists [default: True]
Created	date/time	Time stamp for record creation

Water Analysis Laboratories: tbl_Laboratories		Water chemistry sample analysis laboratories
**Laboratory_ID*	GUID	Unique identifier for each record
Laboratory_name	txt 100	Name of the laboratory facility
Address_1	txt 255 †	Address of the laboratory facility
Address_2	txt 255 †	Address of the laboratory facility
City_name	txt 50 †	City
State_code	txt 50 †	State code

Zip_code	txt 5 †	Zip code
Zip_code_extension	txt 4 †	Zip plus 4 code
Primary_contact	txt 50	Name of the primary contact at the laboratory
Telephone	txt 10 †	Telephone number of the laboratory facility
Laboratory_notes	memo	Comments about the laboratory and/or its track record

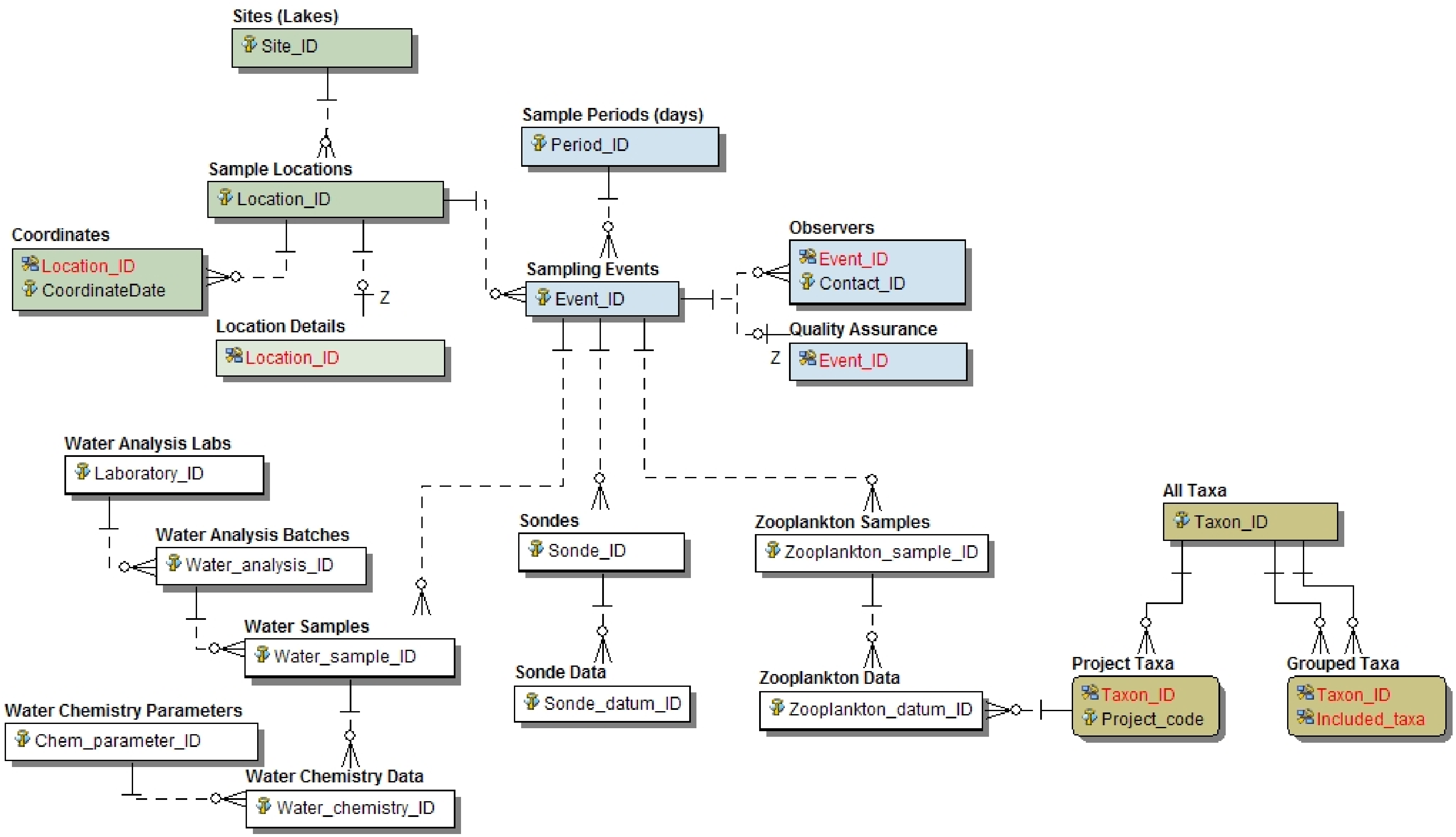
Water Sample Analysis Batches: tbl_Water_Analyses		Water chemistry sample analysis batches
**Water_analysis_ID*	GUID	Unique identifier for each record
`Laboratory_ID	GUID	Unique identifier for the laboratory facility that processed the water chemistry samples
Sent_date	date/time	Date on which the water samples were sent to the laboratory
Process_date	date/time	Date on which the samples were processed
Received_date	date/time	Date on which the sample results were received
QA_notes	memo	Comments about the quality of the chemistry sample and/or its analysis
Water_analysis_notes	memo	Comments about the water chemistry analysis batch

Water Samples: tbl_Water_Samples		Water chemistry samples
**Water_sample_ID*	GUID	Unique identifier for each record
`Event_ID	GUID	Unique identifier for the data collection event
Replicate	byte	Sequential replicate number (e.g., 1, 2, 3, etc.)
Sample_vol_ml	integer	Volume of the sample, in milliliters [default: 1000, valid range: 100-1000]
`Water_analysis_ID	GUID	The batch of samples with which this sample was sent for water chemistry analysis
Entered_date	date/time	Date on which data entry for this sample occurred
Entered_by	txt 50	Name of the person who entered the data for this sample
Water_sample_notes	txt 255	Comments about the water chemistry sample

Water Chemistry Data: tbl_Water_Chemistry		Water chemistry data
**Water_chemistry_ID*	GUID	Unique identifier for each record
`Water_sample_ID	GUID	Unique identifier for the water chemistry sample
`Chem_parameter	txt 25	Water chemistry parameter
Chem_parameter_value	single	Value of the parameter
Chemistry_QA_flag	txt 50	Quality assurance flag
Water_chemistry_notes	txt 255	Comments about this record

Water Chemistry Parameters: tlu_Water_Chem_Parameters		Lookup table of water chemistry parameters
**Chem_parameter_ID*	txt 25	Unique identifier for each parameter
Parameter_def	txt 255	Definition of the parameter
Chem_parameter_units	txt 50	Units in which parameter data are stored
Chem_parameter_notes	txt 255	Comments about this parameter

Figure 1. The entity relational diagram (ERD) for this protocol, with lines between rectangles indicating parent-child relationships between tables. One-to-many relationships (i.e., where each record in the parent table may have several associated records in the child table) are indicated by crow's feet connectors, and one-to-one relationships by single-line connectors. Shaded rectangles represent the standard data tables for network databases, and rectangles without shading represent project-specific tables. Standard tables may also contain project-specific fields, definitions and data ranges, as noted in the table descriptions.



CCAL ANALYTICAL METHODOLOGY The Cooperative Chemical Analytical Laboratory (CCAL) is a cooperative laboratory operated by Oregon State University and the U.S. Department of Agriculture, Forest Service. CCAL specializes in analysis of nutrient research samples for lake, stream, precipitation and groundwater. (**CCAL** 3200 Jefferson WayCorvallis, OR 97331)

Analysis	*Method # with Specifications and Modifications
Alkalinity	403, Procedure 4c, titrate to pH 4.5. Modifications: Use 0.02N Na_2CO_3 and 0.02N H_2SO_4
Ammonia	417F.
Calcium	303A; flame atomic absorption spectroscopy. Modifications: nitrous oxide/ acetylene flame. Addition of 1 ml 50,000 mg/1 lanthanum oxide to 10 ml sample to control ionization.
Carbon, Dissolved Organic	5310B.
Chloride	4110B.
Specific Conductance	205; Wheatstone bridge.
Magnesium	303A; flame atomic absorption spectroscopy.
Nitrate	418F. Technicon industrial method 100-70W; different formulations for color and ammonium chloride reagents.
Nitrogen, Total Kjeldahl	Kjeldahl digestion: H_2SO_4, $CuSO_4$/KC1, Nessler finish.
pH	423; Calomel reference electrode, glass pH electrode, temperature compensator.
Phosphate- Ortho	424F. Modifications: Ascorbic acid reagent 2g/100 ml.
Phosphorous- Total	424C, 424F. Modifications: microwave digestion 60 minutes, 50 ml analysis volume, ascorbic acid reagent 2g/100 ml.
Potassium	303A; flame atomic absorption spectroscopy.
Silica	Technicon industrial method 105-71W/B.
Sodium	303A; flame atomic absorption spectroscopy.
Sulfate	4110B

*Method numbers refer to Standard Methods For the Examination of Water and Wastewater 15th Edition, 1980, except sulfate and chloride Standard Methods For the Examination of Water and Wastewater 17th Edition, 1989.

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Calibration Log

Date	Pre/ post	Temp c	Depth ft	DO mg/L	SpCond mS/cm	pH		ORP mv	Turbid ntu		Chl ug/L	
						7	10		0	10	0	
	pre											
	Calib											
	pre											
	Calib											
	pre											
	Calib											
	pre											
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	pre											
	Calib											
	pre											
	Calib											

Olympic National Park: Lake Crescent Lab

Lake:

Probe Log

Parameter	Probe code	Serial #	Manufacture date	Purchase Date	Expiration date (expected)	

OLYMPIC NATIONAL PARK: LAKE CRESCENT LAB

LARGE LAKE MONITORING FIELD FORM

SITE: ____________________ **DATE:** ________________

OBSERVERS: ____

SONDE DEPTH PROFILES

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

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STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

STATION: ______ TIME: ______ SONDE DEPTH: ______ SECCHI: ______

NUTRIENTS:

STATION: ______ TIME: ______ DEPTHS: ______________________________

STATION: ______ TIME: ______ DEPTHS: ______________________________

ZOOPLANKTON:

STATION: ________ DEVICE________________ DEPTH: R1: ______R2_______R3______

STATION: ________ DEVICE________________ DEPTH: R1: ______R2_______R3______

COMMENTS:

Plankton Enumeration

Lake:________________________ Sample ID:____________________

Sample________________________ Count observer:______________

[d]Volume filtered:_____________ [[c]Sample Volume]:____________

Olympic National Park
Lake Crescent Lab

Taxa	Aliquot Counts (aliquot volume = ____ ml)										[a]Total # Inds.	[b]Total aliquot volume	Number per liter of original H_2O =a/(bd/c)
	1	2	3	4	5	6	7	8	9	10			

Remarks: